TEHRAN LONG TERM URBAN RAIL PLAN

EXECUTIVE SUMMARY
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TUSRC, Tehran Urban and Suburban Rail Company

SYSTRA, French urban and rail transport engineering company

Thanks to all the people who significantly contributed to the meetings, brainstorming sessions and seminars, and who provided helpful comments and suggestions.

And grateful thanks to TCTTS who expertly participated in the study in processing the traffic forecast model.
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction and Methodology</td>
<td>1</td>
</tr>
<tr>
<td>Objectives of the study</td>
<td></td>
</tr>
<tr>
<td>Methodology set up for the study</td>
<td></td>
</tr>
<tr>
<td><strong>Tehran Background</strong></td>
<td>4</td>
</tr>
<tr>
<td>Tehran urban development</td>
<td></td>
</tr>
<tr>
<td>Greater Tehran urban development</td>
<td></td>
</tr>
<tr>
<td>Tehran transport situation</td>
<td></td>
</tr>
<tr>
<td>Tehran future transport demand</td>
<td></td>
</tr>
<tr>
<td>Tehran future transport structure</td>
<td></td>
</tr>
<tr>
<td>Tehran economic wealth</td>
<td></td>
</tr>
<tr>
<td>Previous studies</td>
<td></td>
</tr>
<tr>
<td>Tehran natural constraints</td>
<td></td>
</tr>
<tr>
<td><strong>Objectives and principles to guide the urban rail network design</strong></td>
<td>11</td>
</tr>
<tr>
<td>Walking distance and urban city coverage</td>
<td></td>
</tr>
<tr>
<td>Trip duration on the urban rail network</td>
<td></td>
</tr>
<tr>
<td><strong>Basic Concepts and Design of several network scenarios</strong></td>
<td>14</td>
</tr>
<tr>
<td>Concept of rail services hierarchy</td>
<td></td>
</tr>
<tr>
<td>Connectivity and concept of station hierarchy</td>
<td></td>
</tr>
<tr>
<td>Concept of rail systems hierarchy</td>
<td></td>
</tr>
<tr>
<td>Process of network scenario design</td>
<td></td>
</tr>
<tr>
<td>Design of 4 network scenarios</td>
<td></td>
</tr>
<tr>
<td><strong>Multicriteria comparison of the network scenarios</strong></td>
<td>21</td>
</tr>
<tr>
<td>Nearly 30 selected indicators</td>
<td></td>
</tr>
<tr>
<td>Utility function</td>
<td></td>
</tr>
<tr>
<td>Weighting system selected for Tehran</td>
<td></td>
</tr>
<tr>
<td>Weighting Option 1</td>
<td></td>
</tr>
<tr>
<td>Weighting Option 2</td>
<td></td>
</tr>
<tr>
<td><strong>Tehran Long Term Urban Rail Plan</strong></td>
<td>24</td>
</tr>
<tr>
<td>Refinements and adjustments</td>
<td></td>
</tr>
<tr>
<td>Hierarchy and connectivity of the network</td>
<td></td>
</tr>
<tr>
<td>Characteristics of the Express lines</td>
<td></td>
</tr>
<tr>
<td>Characteristics of the Urban lines</td>
<td></td>
</tr>
<tr>
<td>Complementary Tram/BRT lines</td>
<td></td>
</tr>
<tr>
<td>Monorails lines</td>
<td></td>
</tr>
<tr>
<td>Hierarchy of the stations</td>
<td></td>
</tr>
<tr>
<td>Support to the urban organization</td>
<td></td>
</tr>
<tr>
<td>Network efficiency</td>
<td></td>
</tr>
<tr>
<td>Support to Tehran regional role</td>
<td></td>
</tr>
<tr>
<td>Construction issues</td>
<td></td>
</tr>
<tr>
<td>Capital costs assessment</td>
<td></td>
</tr>
<tr>
<td><strong>Strategic role of Tehran long term urban rail Plan</strong></td>
<td>34</td>
</tr>
</tbody>
</table>
Tehran needs an efficient Public Transport System

Greater Tehran is currently one of the most populated great cities in the world with an estimated population of around 14 million inhabitants. 12 million motorized trips are daily recorded in Tehran Municipality. Improving the Public Transportation conditions has become crucial in Tehran when the increasing road congestion jeopardizes economic efficiency of the city as well as air quality. In the near future, transportation will have a significant role in supporting the development and reinforcing Tehran position as a high-ranked world city.

Due to the important changes in the transport supply and the great modifications of the land use of Tehran since the SOFRETU studies in the 1350’s AH, it has become essential to confirm or update the urban rail strategy development.

Undeniably, Tehran transportation system will have to meet not only the growing passenger demand but also the urban development expansion of the city; it will have to satisfy the inhabitants rising expectations for quality of life and preservation of the environment.

Moreover, there will be an increasing need of land-use management and control of the urban space to facilitate the implementation of the future urban rail lines, which has to be considered in the context of an updated Tehran Urban Master Plan.

The future urban rail network will have to fit with the spatial transportation demand according to the urban development perspectives. The integration of all needs and natural limitations will have to be taken into account while bearing in mind that the final recommended urban rail network will have to be realistic and affordable.

This report is the executive summary of a complete set of volumes that punctuated the main steps of the study.

Objectives of the study

In this context, TUSRC appointed SYSTRA in mid-2005 and fixed the major objective for the “Tehran Rail Public Transport Long Term Development Study”: the achievement of an efficient urban rail network by the year 1409 AH.

Methodology set up for the study

With the aim of densely serve Tehran Municipality and to further link the surrounding satellite cities, Tehran Long Term Urban Rail study carried out by SYSTRA is supported by a proved scientific and rational method adapted to Tehran specific characteristics; it comprises the main following issues:
- In-depth analysis of Tehran backgrounds which encompass urban and economic features, transport conditions and natural constraints.
- Identification of objectives and principles for Tehran Long Term urban rail plan.
- Recommendation of urban rail future levels of service.
- Sizing of Tehran Long Term Urban Rail Network, considering the previous issues in the context of Tehran future economic wealth.
- Concepts and principles for the design of urban rail networks.
- Agreement on a well proved multicriteria analysis specifically adapted to Tehran context to compare several urban rail network scenarios.
- Design process of several network scenarios supported by the whole previous issues.
- Recommendation of the scenario which fits the best with the objectives after the multicriteria analysis.
- Refinements and adjustments to finally propose Tehran long term urban rail Plan.

The result of this methodology is that Tehran long term urban rail Plan integrates 4 express lines and 8 urban lines with a total length of 430km. The effect is an efficient hierarchy of services which is achieved by 5 complementary Tram lines of nearly 60km.
Tehran Long Term Urban Rail Plan at a glance

- 4 Express lines 179Km
- 8 Urban lines 261Km
- Total length 430Km
- 5 complementary Tram lines 60km
- 1 monorail line sketched
- 13 Main interchange stations
- 54 transfer stations
- 19 Park & Ride facilities
- 10 Public Transport hubs in connection with Bus, Railways or Airports services
- 10 million planned daily passengers
An in-depth study of Tehran current situations is crucial to understand the organization and functioning of a city. The consideration of the long term trends is even more essential to define the most suitable objectives for Tehran future long term urban transport. 3 main issues, which are the sound bases of a city functioning, are examined: Urban development, Transport development and Economic development.

Specific focus is given to Tehran Municipality as fixed in the study scope, but consideration is also given to Greater Tehran because of the interrelationship of Tehran and Greater Tehran functioning. The natural conditions which are very specific to Tehran geographic location complete Tehran background study. Attention is paid also to the previous Public Transport studies to enlighten the design of the future urban rail network. The key findings regarding Tehran background encompass the following issues:

Tehran Municipality is presently organized according to a monocentric urban organization. It can be summarized by the existence of a major CBD (districts 6, 7, 11 and 12) which concentrates the commercial activities, surrounded by several residential areas.

The general conclusions of the future trends in terms of population distribution are a higher development of the northern and eastern part of Tehran Municipality and a lower development for the south of the city and the districts 21 and 22.

Nevertheless, the proposals regarding Tehran future Master Plan especially highlight the need of urban activities concentration in specific areas, already existing or planned to be developed. These proposals are taken into consideration as urban centers to serve with the future urban rail network.
The already existing polycentric urban development of Greater Tehran is planned to be reinforced in the future; keeping an unbalanced east/west population distribution with Karaj and Islamshahr as the 2 most populated areas.

This urban development is taken into account for Tehran future urban rail network design, with the satellite cities related to Tehran Municipality core, as indicated beside.

Thus, 6 corridors of development are taken into consideration to be potentially linked to Tehran through 6 gateways. A connection to Karaj exists already with the suburban line n°5.

Some other existing national railway facilities could be re-used for the establishment of the suburban part of the future urban rail network.
The future urban rail network has to take into consideration the existing and committed lines of Tehran metro network, which were lines 1 to 5, at the early stage of the study. They have a total length of about 123km inside Tehran Municipality.

Secondary existing and planned railways stations are also considered to be connected to the future urban rail network. They are mainly located in Greater Tehran where the link to Imam Khomeyni International Airport is obviously taken into account.

Finally, Tehran main highways gateways are identified to possibly develop Park & Ride facilities in order to limit the car use by transferring the trips to the urban rail.

One of the objectives of the future urban rail network will be to serve the outer of Tehran. Public transport hubs such as the 4 existing intercity bus terminals, Mehrabad airport and Shoosh main Railway Station are identified.
The currently daily motorized trips are estimated to around 12 Millions; by the year 1409 AH, around 19 million of motorized trips are expected daily, including trips coming from the satellite cities, which represent nearly a 60% growth in 25 years.

To cope with the growing motorized trip demand will require adequate measures to orientate the demand towards the public modes if considering the car ownership growth trends.

In fact, Tehran car growth is impressive with a huge impact on the poor air quality but also a significant impact on road safety. It is said that the total number of private vehicles has increased of more than 100% between 1369 AH and 1383 AH, especially the last few years.

Even if measures of car use restriction have been already taken such as the widening of the CBD restricted car area and plate number alternate circulation as well as the development and renewal of the public bus fleet, one alternative is definitely the development of an appropriate urban rail network.

By the year 1409 AH around 8.5 million trips should be accommodated by public transport modes, both public buses and urban rail modes.

The modal share of public transport is thus expected to be 45% of the volume of motorized trips. This represents a great change with respect to current modal share, where public transport hardly represents 1/4 of the total motorized trips.

19 million motorized trips are estimated in 1409 AH, of which 45% would be accommodated by public modes.
It is essential to consider the future trends in the transportation demand, in order to propose the most appropriate combination of urban rail lines that fit the demand structure and optimize the travel time of Tehran inhabitants.

The desire lines structure come from traffic forecasts of TCTTS and provide a skeleton which represent a sound basis for the future urban rail network structure inside Tehran.

In addition are also considered the movements related to the satellite cities showing their respective importance.

Desire lines are guidelines to design the future urban rail network.
The investment capacities for urban rail transport projects are estimated as a proportion of the GDP. International Association of Public Transport indicates that around 0.5% of city’s GDP is dedicated to public transport investments in Europe, on average; up to 1.2% when urban rail projects are in the preliminary stage of implementation.

For Tehran case, 2 development steps are thus considered: an investment rate of 1.2% of Tehran GDP, when there is a huge need of urban rail development till 1395 AH; then a rate of 0.75% of Tehran GDP to enable continuing the urban rail implementation.

Growth assumptions are taken for Tehran GDP, in a range of 3% to 6% up to 1409 AH.

Tehran potential urban rail investments are thus assessed between 11 Billion US$ to 15 Billion US$. On this basis, a preliminary sizing of the urban rail network indicates a range from 200km to 350km of new urban rail lines.

200 km up to 350 km of new urban rail lines are estimated able to be implemented.
An in-depth review of 5 major studies highlights the advantages and restrictions of the proposed networks, which considered different systems and corridors. These studies are considered when designing the future urban rail network.

Finally, other issues to take into consideration are the natural environment constraints such as the specific topography and geology of Tehran, the seismic conditions.
Objectives and principles to guide the urban rail network design

SYSTRA identified Tehran major transport stakeholders and authorities directly concerned by Tehran long term urban rail network. Objectives and principles regarding the functions and role of the future urban rail lines were associated to each transport party, as follows:

- Tehran Municipality and the National authorities will be looking for optimizing the use of transport funds, strengthening Tehran regional and national role, protecting the environment and forecasting a sustainable development: principles of urban and economic support and contribution to sustainable transportation were deduced to design Tehran long term urban rail network,

- The network operator, the metro company, will tend to minimize the cost operations and will be looking for maximizing the benefits, and therefore looking for operation efficiency,

- The contractors will ask for minimizing the construction constraints and duration,

- And eventually, the future passengers that will be transported; they will ask for the best conditions of transport on the future urban rail network and the greatest network attractiveness. This will lead to define appropriate levels of service to satisfy the passenger expectations.
Objectives and principles to guide the urban rail network design

The most important principles are certainly the levels of services which have to be carefully chosen, adapted to Tehran, in order to help the designing of an efficient and attractive urban rail network:

- To be the heart of the Public Transportation
- To be in a position to compete with the private modes.

Two important levels of services are chosen, which are essential for the sizing of the future urban network and the structure of the network:

- The accessibility to the network which is measured by the walking distance to access to the stations.
- The accessibility to the urban activities which is measured by the trip duration on the rail network.

These 2 levels of services are obviously interrelated. Indeed, the walking distance directly impacts on the network station spacing and therefore on the commercial speed and the trip duration. The following levels of services are proposed as targets for the long term. They reflect the preponderance that should have the urban rail network in Tehran urban life.

In the long term, it is proposed that all the inhabitants of the dense areas of Tehran Municipality should access to an urban rail station within a radius of less than 800m from their home or job, except in the car restricted area, where it is proposed a better supply and to limit the walking distance to less than 600m.

**Walking distance and city urban coverage**

On one hand, the walking distance to the stations should be attractive for the passengers and therefore should be minimized. On the other hand, too many stations would tend to reduce the commercial speed and therefore to limit the competitiveness with the private modes. So an adequate compromise has to be considered.
Due to the wide Tehran area expanse, these targets lead to recommend two levels of services:

- One which will supply an average commercial speed of around 50 to 60kph. This will induce a station spacing of about 2,500 to 3,000m.
- One which will supply a more standard average commercial speed of around 30 to 40kph. This corresponds to a station spacing of around 1,000 to 1,500m.
The levels of service previously determined lead to propose a hierarchy between the transport functions, which have to be interrelated:

1. **Express level:** Supplying a 50-60kph commercial speed, this level can serve both Tehran Municipality and Greater Tehran. This service will be based essentially on fast access to the main urban activities and will serve in particular all the national and international hubs.

2. **Urban level:** Supplying a more standard 40-40kph, this level will serve mainly the dense areas of Tehran Municipality; it will be based on high level of supply (headways, capacity) and will be integrated with express level through interchanges.

**Concept of Rail services hierarchy**

The concept of urban rail network design is built on complementary and integrated services, as presented beside.

In addition, a third level is assumed to answer more local transport needs and to feed the 2 other levels of service.
Connectivity and concept of station hierarchy

Public transport connectivity is defined as the ability to provide service to a maximum of trips through the optimal integration of lines, schedules, fare and information systems and modal transport facilities.

As far as Tehran long term urban rail network is concerned, a double objective guides the design in order to optimize the network connectivity:

1. To promote a good support to the urban development by offering several options to the passengers in a specific urban area, especially the existing and planned urban centers and facilitate their trips.

2. To facilitate the passenger transfers by well planned transport integration in order to increase the attractiveness of the urban rail but also more generally to increase the attractiveness of the Public Transport. In that case, transport connectivity integrates in a same place the different levels of services of the urban rail itself, but also when appropriate, the other public transport modes and the private modes.

Definitions are mentioned hereafter:

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<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS</td>
<td>2 urban rail lines</td>
</tr>
<tr>
<td>MIS</td>
<td>2 express lines or at least 3 lines</td>
</tr>
<tr>
<td>TH</td>
<td>Ti or MIS + other modes</td>
</tr>
</tbody>
</table>

TS: Urban Rail Transfer Station  
MIS: Urban Rail Main Interchange Station  
TH: Transport Hub; it connects Bus terminals, Airports, Railways Stations or/and Park & Ride facilities
Several types of urban rail systems answer to Tehran specific needs in terms of urban rail systems. The diagram beside summarizes the commonly used classification, based on capacity, commercial speed and segregation of the right-of-way from the surface modes.

Considering the size and the density of the city and the relations with Greater Tehran in the future, MRT systems are recommended, because they are already implemented. The aim is to standardize the rail systems to optimize costs.

LRT could be chosen if the demand appears to be low. Monorail systems which are generally dedicated to specific services could be chosen to serve Tehran Exhibition centre for example. Tram or BRT systems would complement the MRT systems when the ridership is lighter, if the surface implementation is feasible.
Indeed, Express Lines must have a relatively straight alignment or with long radius to guarantee higher commercial speed and sharp curves are avoided in the design of Express Lines.

SYSTRA methodology consists in sketching the express lines first and then completing the whole network with the urban lines in a two steps process which concerns all the various network scenarios; each step being evaluated with a simplified multi-criteria analysis.

The design of network scenarios is a long and iterative process which has to permanently consider all the previous issues which fixed a common frame of design for the various scenarios: numerous Tehran background aspects, objectives for the future urban rail network, target sizing of the future urban rail network, concepts of hierarchy.

The network scenarios design is an iterative process because every issue has to be carefully taken into consideration, always keeping in mind the target sizing. The process starting point is based on the committed lines grid (lines n°1 to n°5).

Since it is considered the Express lines represent the backbone of the urban rail network and due to greater alignment constraints when implementing them, it is appropriate to first identify the future express corridors before identifying the urban ones.
Basic Concepts and Design of several network scenarios

Potential Express lines design and combination

Because of the two transport functions of the future express lines: to serve Tehran Municipality and to possibly link the satellite cities; it is convenient to start the sketching by the identification of the future possible gateways where the express lines will go by, between Tehran and the satellite cities, even if the scenarios focus on Tehran Municipality.

The proposed express lines will try as much as possible to serve the most significant areas inside Tehran municipality, especially the existing and planned urban centers of Tehran future Master Plan, keeping their transport functions as originally defined, i.e. going rapidly through Tehran Municipality and serving the satellite cities corridors. Due to Tehran area expanse as well as the satellite cities possible corridors, the proposals include scenarios with 2, 3 or 4 express lines.

The proposed scenarios are presented within 4 families of express lines combinations:

**Family I:** The Express Network is composed of 2 lines. These two lines have a unique intersection between them.

**Family II:** The Express Network is composed of 2 lines. The two lines will have 2 intersections between them.

**Family III:** The Express Network is composed of 3 lines. One of the three lines will be serving the north of the city, considering the new importance of this part of the city in terms of population distribution and its future role as a major commercial and administrative area.

**Family IV:** The Express Network is composed of 4 lines; it is derived from Family III with an additional Express line.

Potential urban lines design and combination

The starting point of the sketching process of the urban lines is based on previously selected express lines scenarios. The completion of the network scenarios with the sketching of the urban lines is established according to the long term objectives with regard to the specific transport functions which are assigned to the urban lines:

- To serve the densest areas, with the guidance of the desire lines
- To serve the urban centers
- To offer links between urban centers & transport hubs
- To strengthen the network connectivity in offering an adequate number of main interchange stations,
- To complement appropriately the express lines so as to form an integrated network

Design of draft network scenarios

Based on this long iterative process, 11 draft network scenarios were presented, discussed and commented.
Basic Concepts and Design of several network scenarios

11 draft network scenarios

Design of 4 network scenarios

Revisions and new proposals were submitted after additional site visits which provided new guidelines for the scenarios design. Finally, from the 11 draft scenarios, 4 network scenarios were selected on the basis of a simplified multicriteria comparison.

The 4 network scenarios were refined, detailed and then tested through the multicriteria analysis presented hereafter and with the help of TCTTS traffic forecast model. The objective is to select the one which fits the best with the previous fixed objectives.
Basic Concepts and Design of several network scenarios

Network Scenario 1

2 Express lines
10 Urban lines

Network Scenario 2

3 Express lines
9 Urban lines

Network Scenario 3

3 Express lines
9 Urban lines

Network Scenario 4

4 Express lines
8 Urban lines
A multicriteria analysis allows the comparison of the 4 network scenarios in order to recommend the most appropriate long term urban rail network for Tehran. The advantages of such a method are to:

- Enable a wide range of criteria and indicators at the same time.
- Underline some major criteria by giving them a more important weight.
- Easily calculate the utility function as a linear combination of the defined indicators.

The multicriteria analysis offers the possibility of ranking the network scenarios in maximizing the utility function. Criteria and indicators generally reflect the different points of view of every transportation party through their related areas of relevance and associated objectives. This type of multicriteria assessment, which was already proved in other foreign cities cases such as Budapest, Beijing, Shanghai or Dubai, was specifically adapted to Tehran objectives.

Nearly 30 indicators were specifically defined to evaluate the network scenarios, divided into the 6 identified areas of relevance. Those indicators were approved as well as the criteria weighting system during a seminar organized by TUSRC in October 2005, all Tehran Transportation stakeholders being present.

It should be noted that the criteria, indicators and weighting system were agreed before the network scenarios design in order to avoid any bias in the criteria definition or weighting.

Definition of criteria and indicators to evaluate the network scenarios
Multicriteria comparison of the network scenarios

Utility function

The utility function $U(x_1, ..., x_n)$ is defined as a linear combination of the defined criteria ($x_i$) as follows:

$$U(x_1, ..., x_n) = k_1 x_1 + ... + k_n x_n$$

$k_i$ corresponds to the weight given to the indicator ($x_i$).

Weighting system selected for Tehran

The aim of a criteria weighting system is to assess the robustness of the network scenarios when they are confronted to contrasted transport planning policies. Generally, several weighting options attach more or less importance to some of the objectives which support the future urban rail network. Several options were proposed to finally select the two following options, agreed during the 2005, October seminar.

Weighting Option 1

It consists of the average weightings proposed by the different attendees of the multicriteria seminar; in which a flat weighting is applied to the indicators, $k_i = 1$. This option attaches importance mainly on the attractiveness of the network and also on the urban impacts and the construction issues.

Weighting Option 2

It corresponds to a policy which tends to optimize the urban rail network implementation; the major importance is concentrated on the construction difficulties and the investments. This option is considered as a balance between the most important transport areas: the network attractiveness, the construction issues and the costs. In this option, the network attractiveness has still the highest weight compared to the other areas.
Multicriteria comparison of the network scenarios

It should be stressed that the network scenario ranking is similar in both of the two weighting options and network scenario 4 gets the best ranking. Presented below is the ranking from the best notation to the lowest:

1. Network scenario 4
2. Network scenario 2
3. Network scenario 1
4. Network scenario 3

Network scenario 4 is then the one recommended by SYSTRA to be refined and improved during the last step of the study.
Refinements and adjustments

Some adjustments and complements are then proposed to refine the network scenario 4 design, based on several discussions and meetings with TUSRC, TCTTS, BOOM SAAZ GAAN, Tehran Urban Development Institute, TGIC and other transport and urban planning stakeholders. The objective is to:

1. Improve the urban city coverage: adjustments of lines n°8 & n°7 are proposed as well as development of complementary tram/BRT services
2. Reinforce the connectivity: adjustments of lines n°6, n°9 and Express lines II, III & IV are proposed,
3. Strengthen the urban integration: adjustments to line n°9 are proposed,
4. Fill a gap of services: additional monorail service is proposed, dedicated to Tehran Exhibition center

After integrating these modifications, the recommended network scenario 4 is named “Tehran Long Term Urban Rail Network”.
Hierarchical and connectivity of the network

Tehran Long Term Urban Rail Network has a total length of 430km, of which more than 300km are new alignments; it will serve 276 stations inside Tehran. The network has a balanced distribution of 4 Express lines and 8 Urban lines between the east and west of the city, including the existing and committed lines n°1 to n°5. All the lines are organized in complementary services through 54 transfer and 13 main interchange stations, which provide an excellent connectivity to Tehran other transport modes and to Tehran outer gateways. The connectivity is strengthened by the existence of Express lines I and II crossing the city and by the loop around the CBD formed by the Express lines III and IV.

5 Tram/BRT lines of around 60km are also sketched to perfect and feed Tehran urban rail lines; they are assumed to supply a more local service. At last, a dedicated monorail line is also outlined to serve Tehran Exhibition center.
The 4 express lines of Tehran Long Term Urban Rail Network have a total length of 179km inside Tehran. The proposed Express line I is assumed to be an extension of the existing Karaj line n°5. The express lines supply services for a major part of Tehran Municipality and they offer a rapid accessibility to the CBD from the satellite cities:

- Express lines I & II directly serve the CBD,
- Express lines III & IV surround it,

The Express lines serve 4 “North to South” corridors and 3 “East to West” corridors, forming a loop around the CBD.

The 4 express lines have 6 intersections; each one is connected to the 3 others, creating a real convenient rail backbone in the city. They serve 10 of the 13 main interchange stations.
Characteristics of the Urban lines

The total length of the 8 urban lines is around 250km, the new urban lines representing one half. Tehran Long Term Urban Rail Network includes 4 committed urban lines n°1 to n°4, either existing or under construction. Lines n°1 to n°4 diametrically serve the central dense areas of Tehran; they are positioned north south or east-west. They are the urban core of the network, in close integration with the Express lines.

To complete Tehran urban rail network, 4 new urban lines are organized complementary to the express lines and the committed lines. Obviously, they are relatively more distant from the CBD, bypassing the densest central areas of Tehran. Nevertheless, they are significant lines for the future development of Tehran. This constitutes an integrated and dense network which combines the proposed 1st level and 2nd level of hierarchy of level of services.
Complementary Tram/BRT lines

With their successful urban integration, Tram systems are known to increase the attractiveness of the served areas by reducing the congestion and the pollution, strengthening the urban image and participating to the optimized use of the urban space.

In order to strengthen the attractiveness of the public transport system and to better serve some less dense areas, 5 tramway lines of 60km long -or BRT- are sketched. They all provide local services; some are dedicated to new areas of development like District 22 (Tram 01), or Doshan Tappeh urban center (Tram 03 & 05) or the future international center south of Soosh railway station (Tram 04); some complement or feed major lines like Express lines I & III (Tram 01) or like lines n°2 & n°4 (Tram 02). The proposed lines can be operated either with Tram or BRT systems; they all are named “Tram lines”.

Monorail line

Monorail systems are generally identified as dedicated services; they supply relatively limited capacity. One monorail line is outlined to complement Tehran long term urban rail Plan, in order to supply specific service to Tehran International Exhibition center. It can be connected to Express lines III in Sanat Square and to Express line IV; it can be possibly extended towards the east, to connect Urban line n°1.

Key characteristics of the Tram/BRT lines
Tehran Long Term Urban Rail Plan

**Hierarchiy of the stations**

Tehran Long Term Urban Rail Network includes 13 main interchange stations and 54 transfer stations. The functional organization of the interchange stations and the optimization of the passenger transfers between the lines are as important as the location of the stations and their urban impact. Connections between the different platforms have to be carefully planned and well organized during more detailed studies to facilitate the transfer movements and improve the attractiveness of the main interchange stations.

Gare du Nord, Paris, example of main interchange station

Tehran Urban Rail Network is connected with the other Public transport modes through various transport hubs: Bus Terminals, Railways stations and Airports; it serves also 9 Park & Ride facilities, located inside Tehran Municipality, far enough from the CBD to provide efficient service.

At last, Tehran Urban Rail Network will serve Tehran main outer gateways, where it is also proposed to implement some 10 Park & Ride facilities; the aim is to encourage the private mode users to transfer to the urban rail system.
Support to the urban organization

Tehran long term urban rail network provides an excellent coverage of the CBD, the south and north-west areas of Tehran. If it provides a relatively weaker coverage in the north-east, it is well balanced by the services of 3 Express lines which offer rapid links to the higher level of income areas. In addition, significant Park & Ride facilities are proposed to feed these lines. The urban city coverage would reach more than 8 million inhabitants and jobs.

With the complementary Tram lines, Tehran long term urban rail network will directly serve more than 8.5 million inhabitants and jobs.

Tehran Urban Rail Network is absolutely consistent with the long term urban organization which is proposed in Tehran future Master Plan. All the existing and future urban centers are served by at least one Express line.

They are all connected with a transfer or a main interchange station, which are well known to support the urban development and to provide good integration between transport and urbanization.

It has been proved that Tehran Long Term Urban Rail Network provides rapid and direct connections between the different urban centers.

More than 95% of the potential connections between the urban centers are direct or require one transfer which concerns only an express line.

La Défense, Paris Region,
Integration between transport and urban development
Tehran Long Term Urban Rail Network strongly contributes in increasing the modal share of the public modes to some 45% in 1409AH. This corresponds in more than 15 million daily boarding passengers on public transport modes. It helps attracting nearly 10 million urban rail daily passengers. More than ⅓ is planned to concern the 4 Express lines while ½ is planned on the committed urban lines which serve the heart of the city.

The planned daily movements per station highlight the importance of some main interchange stations. The most noticeable, with 500,000 to 600,000 movements per day, are:

- Imam Khomeini station, which accommodates Express lines II, Urban lines n°1 and n°2,
- Azadi station, which accommodates Urban lines n°2, n°4 and n°8.

Mirdamad, Lavizan Forest Park, Nasr, Sadeqiyeh, and Rah Ahan square near Shoosh railway station are also significant interchange stations with more than 300,000 movements per day. At last, some of the major transfer stations are also considerable nodes which are planned to accommodate more than 300,000 movements a day; they concern the CBD stations of the most heavily loaded lines like urban Lines n°1, n°2 and n°4.

<table>
<thead>
<tr>
<th>Planned urban rail ridership in 1409 AH</th>
<th>Daily boarding passengers</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Express lines</td>
<td>2.45</td>
<td>26%</td>
</tr>
<tr>
<td>Urban lines</td>
<td>7.28</td>
<td>74%</td>
</tr>
<tr>
<td>Total urban rail</td>
<td>9.78</td>
<td>64%</td>
</tr>
<tr>
<td>Public Buses</td>
<td>5.55</td>
<td>36%</td>
</tr>
<tr>
<td>Total Public Transport</td>
<td>15.33</td>
<td>100%</td>
</tr>
</tbody>
</table>
It should be stressed that the Express lines are planned to fulfill a double transport function: first, to serve Tehran wide area up to Tehran main gateways, in order to be in connection with Park & Ride facilities, and second, if decided, to be extended to link the main satellite cities of Greater Tehran; an Express service represents indeed a good alternative to the car use.

The Express lines can link all the identified corridors of Karaj, Damavand, Varamin, Pakdasht, Islamshahr and Shahrjir. It has to be noted that Express lines I & III offer the possibility to transfer with 4 urban lines in the south-east area, and therefore provide to Pakdasht and Varamin inhabitants a wide range of destinations inside Tehran. Similarly, Express lines II & IV offer the possibility to connect with 3 urban lines in the south-west area of Tehran, providing also a wide range of destinations inside Tehran for Islamshahr and Shahrjir inhabitants.

Finally, regarding national and international links, Express line IV provides a direct connection to Imam Khomeini International Airport and an additional link can possibly serve IKIA to Sun City and the terminal of line n°1. Besides, a direct express link is proposed between the airports and the national railway station.

At last, when considering the possible extensions of Tehran long term urban rail network to Greater Tehran areas, specific attention is given to the potential integration with the railways development of Greater Tehran.
Construction Issues

All the construction constraints have been looked and highlighted during all the steps of the study: geological, seismic and topographical issues. Numerous site visits and discussions with TUSRC representatives help the understanding of Tehran specific context.

Capital costs assessment

Tehran Long Term Urban Rail Network capital cost is estimated around 16 Billions US$, within the limits of the investments capabilities for the year 1409 AH; which were assessed between 12 and 16 Billion US$.

The construction of the Express lines is estimated to be around 53% of the total, their length representing nearly 60% of the total alignment length to build.
Tehran Long Term Urban Rail Network, with more than 430km in 1409AH, aims at providing Tehran inhabitants a transport service in coherence with Tehran current situation and future trends.

Tehran Long Term urban Rail Network integrates 8 urban lines complementary to 4 Express lines, within an efficient hierarchy which is consistent with Tehran future planned urban organization.

Express lines are conceived as rapid and efficient lines to serve the wide area of Tehran and possibly link Greater Tehran and the satellites cities. Urban lines are specifically dedicated to serve the dense areas of Tehran in close integration with the Express lines through transfer and main interchange stations which provide an excellent connectivity to the network. Connection with the other transport modes is supplied through transport hubs which include Bus, Rail or Park & ride facilities.

Tehran Long Term urban Rail network is planned to attract around 10 million daily boarding passengers in 1409AH, which is considered particularly efficient.

It is relevant to stress the strategic importance of Tehran long term urban rail study. A long term rail Plan represents the heart of a Comprehensive Transport Plan which includes all the modes of transportation and the required tools to manage and control the transport organization. Tehran is a very big city which will continue to grow, and the role of urban rail which is already taken as important, will become essential, because of the expanse area of Tehran and Greater Tehran, because of the rising needs of transport of Greater Tehran satellite cities, the car use, the associated congestion and the increasing level of pollution and also, because of the scarcity of gas in the next years.

Tehran urban rail Plan represents a sound basis to orientate an overall transport policy in Tehran and this study would be a significant contribution to Tehran transport development.